Reproduction is by both transverse and longitudinal fission. In Fig. 3 is represented the ventral, and in Fig. 4 the lateral aspect magnified about 600 diameters. To designate the species it may appropriately bear the name of the host and be *Chilodon megalotrochæ.*

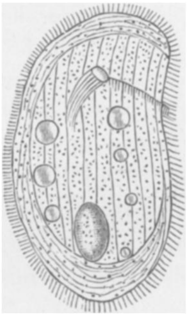

Fig. 3.

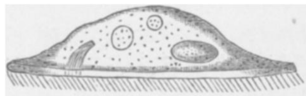

Fig. 4.

FIG. 3.—*Chilodon megalotrochæ*, n. sp., ventral aspect. × 600. FIG. 4.—*Chilodon megalotrochæ*, lateral aspect. × 600.

Chilodon megalotrochæ sp. nov.—Body soft, flexible, ovate, the length once to once and one-half the breadth, somewhat widest posteriorly; the anterior and posterior extremities rounded, the left hand border slightly concave near the anterior apex; lip short, obtuse, inconspicuously directed toward the left; dorsal surface convex, naked, the ventral one flat, finely striated and entirely clothed with short, vibratile cilia, those of the anterior extremity somewhat more conspicuous; the adoral groove shallow, directed backward and outward from the pharyngeal orifice, its cilia under insufficient amplification presenting the aspect of a single projecting seta; nucleus ovate, granular, mesially placed in the posterior body-half; pharyngeal armature more or less curved; contractile vesicles numerous, scattered. Length of body $\frac{1}{400}$ to $\frac{1}{550}$ inch. Habitat, ectoparasitic on the social rotifer Megalotrocha.

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GROWTH, ITS CONDITIONS AND VARIATIONS.

BY CHARLES MORRIS.

IN the story of organic life there is nothing more remarkable than the extraordinary diversity in size between mature animals and plants. The question may well be asked why, in one case, an animal is full grown on attaining the size of an ant, while another gains the bulk of an elephant or whale; and why the lowly moss fails to attain the size of its giant brother, the oak. It might be simply answered that this is a mere question of nutrition, some forms being better adapted to obtain food than others. But the question cannot be disposed of so

readily. Other elements than mere nutrition enter into the problem, and its full consideration requires a review of all the conditions of organic life.

As we ascend in the scale of life we find animals to be possessed of constantly more efficient food-taking organs. From the cilia of the Infusoria and the Sponges we pass to the Cœlenterate tentacles and thread cells, the sucking disks of the Cephalopoda, the pincers of the Crustacea, and the limbs and teeth of the Vertebrata, with numberless intermediate implements of capture. There is a like range of efficiency in the weapons of each sub-kingdom and class of animals. An Octopus, for instance, is a thousand fold more efficiently armed than an oyster, and a man than a mouse. There is a like variation in the rapidity of motion of various animals, some being completely sedentary, others exceedingly active. Their mental powers vary in like manner, from utter obtuseness to great quickness of intellect.

All these differences enter into the question of difference of size, yet they only partly suffice to solve the problem. Great diversity occurs between animals of equal organic efficiency, muscular activity and mental quickness. A rat, indeed, is superior in all these requisites to a cow or a hippopotamus, and a mouse is certainly a more highly organized animal than a whale. It has more efficient and better armed limbs, a greater variety of movements and diversity of habits, and probably superior mentality. In this latter respect, however, the ant is in advance of many massive vertebrates, yet it remains one of the smallest of its own class of insects, the largest of which are certainly not the shrewdest.

If we take a close survey of the animal kingdom, one interesting fact quickly appears, namely, that all the animals below man exist but for three purposes, to obtain food, to escape danger and to reproduce their kind. No other marked purpose in their lives can be seen. They rest and sleep to regain strength, they occasionally employ their excess vigor in play, and curiosity and imitation are now and then displayed, but only strongly in the monkey tribe. Yet the great purposes of their lives, and of lower man as well, are the three above named. Only in higher man do the faculties of curiosity and imitation unfold into the desire for knowledge, and the designed effort to attain advanced conditions, which are the basic principles of the higher mental

evolution. Through the persistent exercise of these faculties man, while retaining in strong measure the three life purposes of the lower animals, has added to them many others of a higher grade. But the faculties which have led to man's mental evolution exist only undeveloped or but slightly developed in the lower-life kingdom, and the whole vigor of these lower creatures is given to the purposes named.

These purposes in reality may be reduced to two. Assault and defence are devoted to a single end, the preservation of individual life. Reproductive activity is devoted to another end, the preservation of race life. These two purposes are, to a considerable extent, in opposition. The animal that is efficient in either is apt to be deficient in the other. The one great object to be attained is life continuance. Any animal tribe that declines in both nutritive and reproductive powers dies out. Only those that are successful in one of these powers can hold their own in the life struggle. But it is simply impossible that any tribe can be markedly successful in both these directions, for two reasons. In the first place great reproductive powers interfere with success in food taking, by increasing the number of applicants for the food supply. It sets up a struggle for existence within the ranks of the tribe itself. In the second place there is a physiological opposition, a struggle for existence between the powers of the individual. Great activity in food getting reduces the reproductive energy. Great reproductive vigor exhausts the muscular and nervous strength. Thus no animal can possess superiority in both these directions, and to the extent that it succeeds in one direction, its powers must decline in the other.

This opposition is displayed throughout the whole range of the animal kingdom. As a general rule the smaller and the shorter lived the animal the greater its fecundity. But small size and short life indicate that its powers of obtaining nutriment are limited, or that its destruction by enemies is great. The continued existence of the tribe, in this case, can only be gained by prolific reproduction. Again, some animals have efficient food getting powers while in the larval state, as in the case of certain insect larvæ, while their nutritive advantages are greatly reduced in the mature state. In such cases we find the larvæ to feed and grow rapidly, while the imago scarcely feeds at all, but devotes all its powers to reproduction. But in the case of certain insects which

are well adapted to procure food in the mature stage, as in ants, the reproductive powers fail to develop at all, except in one or a few members of the tribe, while individual life may be continued for years.

The opposition between these two powers is clearly displayed in other cases. Wherever nutriment is abundant and easily obtainable individual life at once gains an advantage over race life. The reproductive period is retarded. But if nutriment become deficient reproduction is hastened. This has been fully proved by experiments on plants, which, if abundantly fed, grow profusely in leaves and branches, but delay flowering. But if subjected to a starvation process they flower early, and remain stunted individually. Instances of the same kind may be observed in animals, and as a rule deficient nutrition may be said to cause reduction of size and early reproductive activity, while abundant nutrition has the opposite effect.

In this regard an interesting conclusion may be drawn from a general survey of the conditions of animal life. Reproduction means the separation from the body of cells which are the epitome in structure of the whole organism. This separation bears a constantly decreasing relation to the bulk of the whole body as we ascend in the animal series. In the Protozoa the germ-cell takes the half of the body, or in some cases the whole of the body is converted into germs. In the Metazoa a lesser portion of the body is shed as germs. The proportion is great in the lower animals, in some cases extreme, but small in the higher classes, and very minute in the highest. The fact that the shedding of germs is hastened by deprivation of food suggests a reason for this difference. Every higher animal is in a certain sense a colony of coherent cell individuals. This coherence is an indication that they are favorably situated for nutrition. If food fails to come to them they will go to seek it. In other words, the offspring of the coherent cells will become wandering cells. This is very probably a constant effect of the growth of animals, since with every increase in bulk the ability to supply the whole mass of cells with food decreases. In consequence we may surmise that wandering cells are budded off by the fixed cells more abundantly as size increases, with the effect of checking the growth of the animal, and eventually of preventing any further increase in bulk.

At the same time the profuse existence of wandering cells is a necessary preliminary condition to reproduction. These cells, as the writer has already advanced in a former treatise,[1] conjoin and subdivide until from the union of cells, each of which possesses the structural peculiarities of only a minor portion of the organism, are produced cells containing the structural characteristics of the whole organism, and consequently suited to become the germs of new organisms.

Such is presumably the general character of animal life operations. The food-getting powers of Protozoa are very slight. Their cilia are inefficient organs, and only suited to the capture of very minute prey. As they increase in size their power of obtaining sufficient nutriment decreases. Hence division takes place and the offspring become wandering cells, since their chances in the life struggle are thus improved. With higher animals special conditions have rendered the colonial aggregation of cells advantageous, and cell-coherence becomes the rule. By combined effort each cell succeeds in obtaining more food than it could have done by its unaided efforts. But in every case as the size of the individual animal increases, its ability to satisfactorily supply all its hungry cells with food diminishes. The point at which the limit in this direction will be reached depends on the degree of efficiency in the food-taking organs, and also on the quantity of available food, more nutriment being requisite the greater the bulk of the animal.

When this limit is reached, individual life growth ceases. The organic powers remain stationary for a time and then deterioration sets in. This deterioration is apparently a necessary result in all organisms, arising from a gradual failure of the individual life powers, or from inimical organic processes which inevitably arise. That this is really the case, however, is not sure. It is by no means certain that an indefinite continuance of individual animal life might not be possible if the reproductive process were completely checked. It might reasonably be conjectured that if this were possible it would have occurred somewhere in the long range of animal development, during which such an extreme diversity of form and condition was produced. But such a race of animals would certainly be at a disadvantage in the life struggle. Its powers of continuous life must gradually succumb to

[1] AMERICAN NATURALIST, June, July, August, 1882.

starvation, accident, the violence of foes and all the external conditions which oppose individual life continuance. Therefore some degree of reproductive activity is necessary to the continued existence of any animal race, and it is probable that any degree of this activity is incompatible with continuous individual life.

The shedding of wandering cells appears to take place throughout the whole life of the higher animals. They may be found as amœboid corpuscles in the blood at all periods of growth. Only in the lowest forms, however, can they be developed as germs of new individuals at all periods. In all forms above the lowest some organ for their temporary reception must be first produced, in which the earlier stages of development can be passed, since the higher the animal the more unsuited is its germ for immediate self-nutrition. When the sexes become separate this grows more necessary, and individual development must pass through certain phases ere the organs necessary for reproduction are unfolded. Over this unfoldment of organs the nutritive conditions exert an important influence. Very active nutrition acts to check structural development. The writer has treated this subject at length in a fc. paper,[1] and need simply here refer to the case of insects in which structural development is retarded during the active nutrition of the larval stage, and is only actively resumed during the innutrition of the pupa stage. Thus with insects the conditions requisite to reproduction are only completed in the imago stage of development.

It is not alone reproduction that checks growth, since reproduction, under certain conditions, might long continue without that cessation of growth which usually accompanies sexual maturity. But reproduction, to be effective, must be of such a character as to assure the preservation and mature development of at least two offspring to every two parents. This can be done in one of two ways, either by the production of germs in great numbers, if they are left to take their chances of destruction by enemies or hostile natural conditions, or by the production of fewer germs, which are kept under parental protection until the young are able to shift for themselves. Both these processes are exhaustive of vitality. In the case of fish, which shed into the water immense numbers of sperm and germ cells, the physical strength is reduced by great abstraction of vital material. In the

[1] Growth and Development, AMERICAN NATURALIST, July, 1883.

case of land vertebrates, which produce much fewer eggs but furnish these with greater nutriment and give them special care, there is similar exhaustion, as also in the case of mammals, in which a considerable development of the young takes place within the body of the parent. Thus as a rule growth ceases shortly after the period of sexual maturity is reached. The least exhaustive phase of this process is that displayed by the males of mammals, which lose but little vital material and waste little vital strength. They consequently exceed the female in size, yet not inordinately. The conformity in hereditary conditions, and in size of the initial life stage, act to prevent any undue excess in growth of males over females.

The conflict between reproduction and individual energy, however, is but one of the influences affecting the sizes of animals. There are conditions which affect the members of each separate tribe to which we must next advert. Whether two animals shall attain the same size does not depend entirely on whether they are able to obtain the same quantity of food. This is but one element in the problem. Another equally important element is the amount of exertion, physical or mental, necessary to obtain that food. The food is not applied within the body to the single purpose of growth. It is partly consumed in the production of animal heat, partly in recovering from muscular waste, partly in similar nerve recovery, and partly in reproductive activity, while only its excess goes to the formation of permanent new tissue.

As a rule it might be conjectured that cold-blooded animals would exceed the hot-blooded in size. They obtain their heat from without, and use up no nutriment in this purpose. But they are less active and efficient in the pursuit of food, and thus more than lose the advantage which their nutrient superiority might give them. Muscular activity is very exhaustive of nutriment, and we find that the more active animals are usually the smaller. Thus throughout their whole range the Herbivora exceed the Carnivora in size. And of each of these classes the most active species are the smaller. The great Carnivora, the lions and tigers, are only occasionally active. The bears are sluggish in movement. The smaller Carnivora, as the weasel family, are incessantly active. It is the same with the Herbivora. The elephant, rhinoceros and hippopotamus are usually slow moving creatures. The ox family is more active, and the much

chased deer and antelopes are kept in frequent swift motion. In fact the smallest Herbivora are those that trust to flight for safety, the medium sized those that need rapid motion in food getting but are safe from the attacks of Carnivora, or able to defend themselves, while the largest are those which need rapid motion neither for flight nor food getting. The desert-living camel, for instance, must be able to move very rapidly from oasis to oasis. And the horse needs swift motion over the partly barren plains which form its native home. But neither of these has occasion to fly from enemies.

Nervous activity is also repressive of growth, and the larger animals of each tribe are usually the duller mentally. But this is not the case where mental shrewdness replaces activity in the obtaining of food, or where the more intellectual animals possess highly efficient food-taking organs. The cuttle-fish is the largest and probably the most intelligent of mollusks, but its remarkably powerful weapons of assault enable it to obtain much food with little exertion. The same is the case with the elephant, whose trunk gives it special advantages in food getting. In these cases such mental energy as is exercised is correlated with physical sluggishness. In another case, that of the ants, the mental and physical energies are both in high activity, and this is perhaps a main reason why the ants, with plentiful food and no reproductive exhaustion, remain such small members of the insect race.

But a still more important agency in the growth of animals is the efficiency of their weapons of assault and their powers of motion in obtaining them a plentiful supply of food. In all cases the larger animals are those best adapted and situated for obtaining food with the least exercise of muscular and nervous functions. In this latter particular the sedentary animals are at an advantage, but it is far more than counterbalanced by the inefficiency of their means of capture. Unable to go in search of food, they are restricted to such food as they can bring to them by making currents in the water, or which they can capture in passing. To the former purpose the cilia of Protozoa, sponges, the lower mollusks, &c., the winnowing arms of barnacles, &c., are applied; to the latter the tentacles and thread cells of the Cœlenterata. Parasitic animals are also included in this category. None of these animals can grow to a great size, since the quantity of food they can obtain is necessarily very limited.

With respect to active animals their food-taking powers depend on one or more of three requisites, speed of motion, mental quickness and power of weapons. The largest animals among the Carnivora are those which have the highest development of this third requisite, and thus can obtain equal quantities of food with less organic exhaustion. It is not necessary to make a comparison of the weapons of various animals in this connection, as it is evident that there is a steady progression upwards as weapons grow more powerful, from the Protozoan cilia to the Mammalian claws and teeth.

But a highly important influence in this connection is that of special adaptation of animals to particular kinds of food, together with the comparative abundance of this food, and its comparative resistance to capture. The food of carnivorous animals does not tamely submit to destruction. It makes earnest efforts to escape or to defend itself. With animals that depend for safety on flight, and for food on pursuit, the great muscular exertion acts to check growth. Yet if these animals are capable of obtaining plentiful food they may become of considerable size. The weasels and their congeners are adapted to a kind of food which is small in bulk and is only to be obtained by great agility or cunning, often by pursuit through underground burrows. Hence their size is necessarily restricted, since overgrowth would unfit them for their life habits, and thus still further reduce their food supply. Their burrowing prey also are necessarily of small size, from the exigencies of their life habits and the small quantity of food which they are capable of obtaining. On the other hand the much chased deer are grass eaters, and are thus adapted to an abundant food which can be obtained without exertion. They therefore attain a considerable size despite the great muscular exertion which they need for safety. At the same time the larger Carnivora, which feed upon the timid Herbivora, obtain food in large masses, and grow in bulk accordingly, despite their great activity.

With the Herbivora the same rule holds. Their bulk is closely governed by the degree of agility necessary to obtain food, the resistance of this food to capture, its comparative abundance, and the exertion which they need to escape carnivorous foes. The nut-eating rodents, for instance, depend upon food which resists capture, and which can only be obtained in small quantities and

by considerable labor. Thus their food supply is greatly limited. The gnawing teeth of rodents are inefficient weapons as compared with the cutting teeth of Carnivora and the grinding teeth of the large Herbivora. The same remarks might be applied to the food and weapons of the Insectivora. Again, among rodents and in fact among all classes, the tree livers are smaller than the ground livers. They need great agility, their food is usually of reduced quantity, if vegetable food it is usually placed at the extremity of the small branches, if animal it escapes to this extremity, so that great bulk would either reduce the food-getting power, or the safety from danger. The largest arboreal animals are the climbing cats, which obtain their prey by springing, and these are much smaller than the ground-lurking cats. On the contrary the coiling and crushing serpents attain their greatest size in trees, which seem to offer them a special advantage in the capture of large prey.

In regard to those grass and leaf-eating Herbivora which have learned to defend themselves by weapons instead of by flight, and thus to avoid the excessive exertion of their timid relatives, their size is greatly influenced by the degree of exertion necessary to obtain a supply of food; that is, on the abundance of food native to their habitat. The camel, for instance, is native to sandy deserts dotted with occasional grassy oases, so that it needs swift motion and great powers of endurance of hunger and thirst, to enable it to shift from pasture to pasture. The horse also is native to broad, level plains, but sparsely provided with pasturage, and needs swift motion to obtain a sufficient food supply. A similar argument applies to the American bison and the larger deer. These animals, while attaining a considerable bulk, are much smaller than the slugglish tropical Herbivora, the elephant, rhinoceros and hippopotamus, which live among superabundant food, and have little occasion to fear enemies.

Again, as tree-living animals are necessarily small, so are mountain animals of reduced bulk. Though they are in no great danger from carnivorous foes, their food supply is small, and can only be obtained by great exertion. Reference may here also be made to the tribe of birds. These are necessarily smaller than land animals. The element in which they live requires great muscular activity, which increases in a rapid proportion with increase in bulk. Their food supply is also limited, and only to

be obtained by great exertion. But unlike land animals the largest birds are the Carnivora, since the food to which they are adapted is far more abundant than can be obtained by the pecking fruit-eating, or the insectivorous birds. But the largest of all birds are those that have lost the habit of flying, and with it the necessary muscular waste. And of these land birds the largest known to us were those sluggish inhabitants of the Pacific islands, whose habitat was untenanted by large Carnivora, and their food abundant, so that they did not need the activity of the desert-living ostrich.

If now we consider water animals, the considerations here taken receive a remarkable exemplification in the whale, with its bulk so greatly in excess of that of any land animal. An examination of the structure of the great Greenland whale would not lead to this conclusion. It has lost all the weapons on which its land kindred depend. Its teeth have vanished. Its hind limbs have disappeared. Its fore ones are only used for swimming. Its food-getting powers seem singularly reduced, while the food upon which it depends consists of minute, almost microscopic animals. Thus a natural conclusion would be that the whale should be of small bulk instead of gaining such monstrous proportions. But on the other hand its food is superabundant in quantity, and is utterly defenceless against its huge foe. The whale needs no weapons to capture its food. These would be useless and have been lost. All it needs is to rush rapidly through the water with open mouth and swallow the food which it thus collects in great masses. Intelligence would be useless to it, and is greatly lacking. Its muscular waste is comparatively small, since swift motion through the water needs far less exertion than on the land. It has no foes whom it endeavors to escape by flight. Thus there is nothing to hinder its attaining an inordinate bulk. In this whale, and related species of the same general habits, the powers of growth attain their ultimate development.

The same consideration applies to the great sperm whale, which is adapted, indeed, to a food of different character, but seems to obtain as abundant a supply with as little exertion. The remaining water mammals are smaller. They trust to food that is less abundant, and which needs more exertion to obtain. The seals cannot obtain their fish food without great agility, and it is

probable that the huge size of the great sea elephant arises from its being adapted to some less agile and more abundant food than that sought by its smaller kindred. With fish the same rule applies. The powerfully armed sharks far exceed any others in bulk, fish, as a rule, being inefficiently armed and adapted to small sized prey.

If we leave the vertebrates and consider the articulated animals, the same rules hold good. The insects are specially adapted to a restricted food supply, and their weapons are usually such as enable them to obtain food only in small quantities. The sucking, boring and rasping implements with which they work are of no great efficiency, and the largest insects are the strong-flying carnivora with their powerful pincers and jaws. The spiders are equally small, from the minute quantity of food which their cunning brings them. By far the largest articulates are the crustaceans, in whom the pincers have developed into powerful weapons, and who find in their water home larger, more abundant and more easily overcome prey. But in all these cases the size of any particular species is largely the result of the efficiency of its weapons, the size and quantity of the food to which it is specially adapted, and the degree of energy or cunning which it needs to capture its food and to escape its foes.

Thus it would appear that the size of every species of animal has a natural limit, about which it may fluctuate, but from which it cannot widely depart in either direction unless there occurs a marked change in the surrounding conditions or in its organization. Its size depends strictly on the efficiency of its food-taking weapons, the abundance of food to which it is specially adapted, or the mass of food material which it can obtain, the degree of exertion, muscular or nervous, which it needs to obtain this food, the degree of exertion which it needs to escape its foes, and the vigor of its reproductive energy. The latter, however, is a fluctuating element, which acts like the governor of a steam engine. The former conditions control the average size at any fixed period. But if, through a change of conditions, nutrition becomes more abundant, reproduction is correspondingly checked and size increases, while the reverse occurs if nutrition decreases. Thus by a correlation of its two powers of nutrition and reproduction each animal manages to hold its own in the struggle for existence. If, through any causes, an animal tribe falls below the

requisite level in both of these powers, it is in danger of extinction. If it rises above the level some other tribe is in danger of extinction. This latter is a highly important fact, to which further attention will be requisite after some other points have been considered.

We may here speak of the great influence which larval metamorphosis seems to have on the ultimate size of animals. With the invertebrates, as a general rule, the young come into the world half born. They are thrown upon their own resources in a partly developed state, and have a high wall of metamorphosis to climb ere they can reach the stage af maturity. During this larval period they represent animals of a lower grade of organization than the mature form, and more imperfectly adapted to food getting, except in those cases in which the mature form is a degenerated one, or in those other in which the mature form has lost its original adaptation to the food conditions, and thus is forced into immediate reproductive activity, as in the case of many insects. If we take, for instance, the actively feeding caterpillar and compare it with the butterfly, we find the latter, on leaving the pupa case, to be not more than a tenth of the size of its larva, while the new food stock, to which it has become adapted, is much less abundant and easily obtained than that open to the caterpillar. Thus growth force ceases, reproductive activity supervenes, and death of the mature animal quickly follows.

Vertebrates are tided over these larval stages, which they pass either in the egg or in the maternal womb. The loss of life vigor in their case falls upon the mother, not upon the offspring. The marsupials, in which the young are born imperfectly developed, are all comparatively small in size. This may not, however, arise from the cause specified, since the young obtain food from the mother without personal exertion until they have passed through the larval stage. As a rule, as pointed out by Herbert Spencer, the initial size of the animal exerts a vigorous influence upon its ultimate size. If it begins its individual life with large bulk and great food-taking and consuming powers, its growth will be proportionate. He instances the diversity in size of sheep and oxen feeding in the same pastures.

Intelligent selection, as exercised by man upon domestic animals, is capable of producing great variations in size. In the

domestic dog, for instance, a remarkable diversity has been in this way produced. The same effect, though less marked, appears in the other domestic animals. It has become strikingly produced in the horse without design, but merely through diversity in quantity of food, and in the necessary exertion to obtain it in different localities. In these instances we recognize the influence of heredity in preserving variations of chance occurrence. It may be remarked here that man is not the only animal which practices intelligent selection. Bees and ants pursue the same process with their own young, and with remarkable results. Thus with the hive bee a special feeding of one of the worker larvæ yields not only increased size but an important organic development. From being a sterile worker it becomes a functional female, or queen. In the ants the sterile forms often differ widely in size. Dr. McCook measured in one nest nine distinct sizes, the largest being seven times the length of the smallest. Whether this is a result of designed difference of nutrition of the larvæ does not appear, though there are two or three distinct duties in the nest to which ants of distinct sizes apply themselves.

But we have now to consider another phase of the subject which has been of extreme importance in its history. In addition to the influences whose effect upon the sizes of animals we have considered, there is another of equal, if not greater, efficacy. We look upon the tentacle as a weapon of minor power, yet in the cuttle-fish it has become an exceedingly powerful instrument, and through its aid giant animals have been produced. The same may be said of the weapons of the Crustacea, which sufficed, in an early geological period, to yield crustaceans of six feet in length. Even the Medusæ, with their apparently feeble food-taking powers, occasionally attain to great bulk. They are perhaps situated like the whale in the midst of an abundant supply of defenceless food, which can be obtained without special exertion. The defenceless prey of these great sluggish animals are those small creatures which trust to excessive reproductive powers for continuance of their race, and thus have less need of efficient personal defence than with the less prolific.

These cases point to the condition now to be reviewed, that of comparative ability to share in the limited food supply. The struggle for existence is by no means confined to the power of attack and defence, but also takes the form of a struggle to obtain

a full share of the naturally supplied food. This has been one of the most potent agencies in the history of animal development. The living tribes of nature sit down to a bountifully supplied table from which each eagerly seeks to gain a "lion's share" of food. Of those that are adapted to a certain kind of food, on a certain part of the table, the best armed and situated will obtain the most, and increase in size over their less fortunate competitors. On another part of the table animals equally well armed are served with a more meager repast, and thus need greater activity to obtain equal or smaller quantities of food. They consequently decline in size below their better situated relatives. The degree of competition, however, is reduced by the fact that many tribes are adapted to food of quite different kinds from that sought by others. Yet every class of food is eagerly sought for, so that there is everywhere a sharp competition, and the animal so organized and situated as to obtain the most with the least exertion of body or mind, is sure to outgrow all rivals of equal advantages and initial powers of organization. It may be here remarked also that at this great feast of nature the food often resists capture, and is not to be taken without special exertion. Some offers no resistance, some is enclosed in hard or spiny armor, some has active powers of motion and needs to be pursued. Thus the competition is great in degree and in variety, and the sizes attained by the different guests depend greatly on the quantity of food they succeed in obtaining in fixed periods, and the waste of tissue necessary in the struggle.

This competition, while highly influential in keeping existing animals each to its limit of size, was probably, in the geological periods, the most efficient agent in controlling the sizes of animals, far more so than the direct struggle between Carnivora and their prey. A rapid review will show this. In tracing the succession of animals in former ages one fact of importance appears. This is, that the members of the animal kingdom only by slow degrees advanced in the utility of their weapons of attack and defence, in their agility and in their mental ability. In consequence of this successive development the geological periods present us with some highly interesting conditions of animal life, which are of interest in the present connection. Successive waves of life have passed over the earth, each swelling to a cul-

minating point of height and then declining, to be followed by a new wave, and each of superior structure than the preceding. Each wave of life, in fact, has been forced down by the succeeding and superior one, until now the human wave has risen and is forcibly breaking down that which last preceded it.

(To be continued.)

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DR. D. E. SALMON'S CLAIMS RESPECTING THE DISCOVERY OF THE GERM OF SWINE-PLAGUE.

BY H. J. DETMERS.

IN No. 53 of vol. III, of *Science*, pages 155 and fol., appeared an article by Dr. D. E. Salmon, in which he claims priority in the discovery of the cause of swine-plague with reference to my own researches. Since my claims, recently admitted by Pasteur, and in 1880 by the professors of the Royal Veterinary School at Berlin (see page 464 and 465 of the Archiv für wissenschaftliche und práctische Thierheilkunde, vol. VI, part 6), are thus directly disputed, it is incumbent upon me to vindicate them. That Dr. Klein discovered in 1876 microorganisms in the carcasses of hogs that had died of swine-plague, I have nowhere disputed; neither have I expressed any doubt that Dr. Klein may have seen the very micrococci which constitute the cause of the disease. In fact, I have never seen Dr. Klein's report. Only brief extracts of the same have ever come to my knowledge, from which, however, I have not been able to learn that Dr. Klein demonstrated the causal connection of these bacteria with the disease. This proof, absolutely necessary in order to show the parasitic nature of the disease, I was the first to furnish. In special report No. 12, and in the annual report for 1878, of the commissioner of agriculture, can be found a detailed account of my researches. In these I discovered a specific microorganism in the fluids, morbidly affected tissues, and morbid products of the diseased animals, as well when killed by bleeding, as also in the perfectly fresh carcasses of those that had died of the disease. These bacteria were cultivated outside of the animal body, in innocent media, such as milk, mutton broth, and other fluids (see page 37 of the commissioner's special report No. 12, or page 347 of his annual report for 1878).

An inoculation with the bacteria, thus cultivated, reproduced